CDI FY17 Request for Proposals

Empowering decision-makers: A dynamic web interface for running Bayesian networks

Submission Title: Empowering decision-makers: A dynamic web interface for running Bayesian networks

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Science Support Framework Element 1: Science Project Support
Science Support Framework Element 2: Applications
Science Support Framework Element 3: Web Services

In-Kind Match: $41,500.00

List of anticipated deliverables from the project: Functional prototype web application. Source code in USGS Bitbucket and Github repositories.

Lead Cost Center: Woods Hole Coastal and Marine Science Center

Notes, Comments:

Project Description: We propose to build a prototype decision support web interface that utilizes Bayesian networks, where users can investigate the effects of a variety of decision-support scenarios. Users will be able to alter specific parameters to evaluate associated forecast outcomes while considering uncertainty, such as how accelerating sea-level rise may affect shorebird habitat suitability, erosion rates, or inundation risk at a site of interest, or to screen potential groundwater well locations to evaluate potential reductions in streamflow in sensitive aquatic habitats.

Total Budget: $50,000.00

SECTION 1. PROJECT SUMMARY

Project Title: Empowering decision-makers: A dynamic web interface for running Bayesian networks

USGS Principal Investigator (for purposes of contact)**:** Erika Lentz, Woods Hole Coastal and Marine Science Center, 384 Woods Hole Rd., Woods Hole, MA, 02543, 508-457-2238 (office); elentz@usgs.gov

Decision support tools are in increasingly high demand to inform climate change adaptation and resource utilization decisions. From endangered species specialists and natural resource managers to infrastructure developers and city planners, access to information that is sound and actionable is critical for planning over a number of temporal and spatial scales (NRC, 2009). In response to these needs, the USGS has employed a probabilistic modeling approach using Bayesian networks (BNs) to forecast a variety of landscape and natural resource changes. The implementation of this approach has resulted in proven applications that span a number of USGS Mission Areas including: piping plover habitat suitability (Gieder et al. 2014) (Ecosystems); beach/dune morphology change (Gutierrez et al. 2015) (Natural Hazards); shoreline (Gutierrez et al. 2011; Plant et al. 2016) (Natural Hazards) and coastal landscape response to sea-level rise (Lentz et al. 2016) (Natural Hazards; Climate and Land Use Change); and groundwater sources and sustainability (Fienen et al. 2013) (Water). Forecasts are produced in a form that is straightforward and intuitive for decision-making, as they show geospatially and temporally explicit outcomes as well as likelihoods (confidence) for those outcomes occurring. Here, we propose a one-year project to build a prototype decision support web interface that utilizes BNs, where users can investigate the effects of a variety of scenarios on outcomes and their likelihoods.

A BN is a directed acyclic graph intended to organize knowledge about a system (Figure 1). Forecasts are made using statistical inference and joint probability calculations, and the set of all possible node-value combinations forms a conditional probability table underlying a 'trained' network that can be queried for specific characteristics or outcomes. The first phase of the proposed work will develop the open-source backend tools and code to manipulate existing BNs and their associated datasets. We expect that extensions of existing R and Python tools can meet our needs. The second phase of this work will develop a web application platform through which different decision-support scenarios can be explored interactively and viewed on a map. Users will be able to alter specific parameters to evaluate associated forecast outcomes while considering uncertainty. For example, users could explore sea-level rise rates to determine how accelerating sea-level rise may affect shorebird habitat suitability, erosion rates, or inundation risk at a site of interest. In another example, users could screen potential groundwater well locations to evaluate potential reductions in streamflow in sensitive aquatic habitats.

To limit project scope and development risk, we will build the platform – based on our successful USGS Coastal Change Hazards portal – using open source software and precompiled scenarios determined from early-stage stakeholder/end-user engagement. The project PIs have established relationships with the decision-making community via collaborations in structured-decision making workshops (Lentz et al., 2015) and funded projects through the North Atlantic Landscape Conservation Cooperative, the Northeast Climate Science Center, and other DOI partners (FWS, NPS). The PIs also have a long history of sharing information in a variety of formats, including stakeholder meetings and webinars, technical reports, peer-reviewed literature, and in-person workshops. We will work closely with these partners to craft scenarios and receive feedback on the most effective formats to address their particular decision problems within the proposed platform. Usability and data access will be among our top priorities as we develop this platform.

This capability has the potential to be developed into a portable framework to link established BNs directly to available spatial data, for which the proposed work is the seed. Here, the web platform would itself become a modeling tool, where users could investigate any number of scenarios with information from existing maps, crowdsourced data, or their own uploaded datasets. Because the underlying models are BNs, uncertainty would be explicitly quantified in real-time – providing updated confidence levels with every forecast. There is also the potential to integrate with new USGS publications resources, such as incorporating data from ScienceBase to populate metadata fields and utilizing web mapping services.

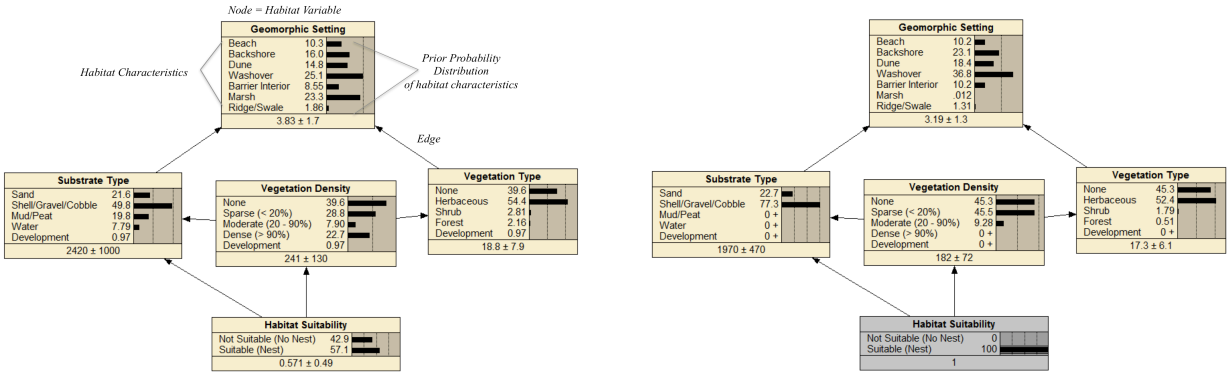

Figure 1. Graphical representation of a Bayesian network showing input nodes that connect to each other and an output node (Habitat Suitability), with an example of how this information can be manipulated to identify key characteristics. Left: prior distributions of variables. Right: Output node set to identify distributions of input variables that correspond to suitable habitat. The ability to manipulate such variables in a web application framework to show changes in space and time is the focus of this proposal.

References

Fienen, M.N., Masterson, J.P., Plant, N.G., Gutierrez, B.T., and Thieler, E.R., 2013, Bridging groundwater models and decision support with a Bayesian Network, Water Resources Research, doi:10.1002/ wrcr.20496.

Gieder, K.D., Karpanty, S.M., Fraser, J.D., Catlin, D.H., Gutierrez, B.T., Plant, N.G., Turecek, A.M., and Thieler, E.R., 2014, A Bayesian network approach to prediction nest presence of the federally-threatened piping plover (Charadrius melodus) using barrier island features, Ecological Modelling, 276, p. 38-50, doi:10.1016/j.ecolmodel.2014.01.005.

Gutierrez, B. T., N. G. Plant, and E. R. Thieler (2011), A Bayesian Network to Predict Coastal Vulnerability to sea level Rise, Journal of Geophysical Research Earth Surface, doi:10.1029/2010JF001891.

Gutierrez, B. T., N. G. Plant, E. R. Thieler, and A. Turecek (2015), Using a Bayesian network to predict barrier island geomorphologic characteristics, J. Geophys. Res. Earth Surf., 120, 2452–2475, doi:10.1002/2015JF003671.

Lentz, E.E., Thieler, E.R., Plant, N.P, Stippa, S.R., Horton, R., and Gesch, D.B., 2016, Evaluation of dynamic coastal response to sea-level rise modifies inundation likelihood, Nature Climate Change, doi:10.1038/nclimate295.

Lentz, E.E., Stippa, S.R., Thieler, E.R., Plant, N.G., Gesch, D.B., and Horton, R.M., 2015, Evaluating coastal landscape response to sea-level rise in the northeastern United States—Approach and methods: U.S. Geological Survey Open-File Report 2014-1252, doi:10.3133/ofr20141252.

National Research Council, 2009, *Science and Decisions: Advancing Risk Assessment*, doi:10.17226/12209.

Plant, N. G., Thieler, E.R., and Passeri, D. L., 2016, Coupling centennial-scale shoreline change to sea-level rise and coastal morphology in the Gulf of Mexico using a Bayesian network. Earth's Future, 4: 143–158. doi:10.1002/2015EF000331.

SECTION 2. ESTIMATED BUDGET

Budget Category	Funding Requested	Matching Funds
1. PERSONNEL SALARIES (including benefits)		
Federal Personnel Total	$0	$35,000
Contract/Collaborator Personnel Total	$41,388	$0
Total Salaries	$41,388	$35,000
2. TRAVEL EXPENSES		
Travel Total (per diem, airfare, mileage/shuttle)	$1,000	$2,000
Other Expenses (e.g. registration fees)	$0	$0
3. OTHER DIRECT COSTS		
Equipment (software, hardware, purchases/rentals)	$0	$4500
Publication Costs	$0	$0
Office Supplies, Training, Other Expenses (specify)	$0	$0
Total Other Direct Costs	$0	$0
Total Direct Costs	$42,388	$6500
Indirect Costs (17.958%)	$7612	$0
GRAND TOTAL	$50,000	$41,500